



# Fish Losses to Double-Crested Cormorant Predation in Eastern Lake Ontario, 1992–97

By Robert M. Ross and James H. Johnson

**Abstract:** We examined 4,848 regurgitated digestive pellets of double-crested cormorants (*Phalacrocorax auritus*) over a 6-year period (1992–97) to estimate annual predation on sport and other fishes in the eastern basin of Lake Ontario. We found more than 51,000 fish of 28 species. Using a model that incorporates annual colony nest counts; fledgling production rates; adult, immature, and young-of-year residence times (seasonal); estimates of mean number of fish per pellet and mean fish size; and a fecal pathway correction factor (4.0 percent), we estimate total annual number of fish consumed by cormorants in the eastern basin of Lake Ontario to range from 37 million to 128 million fish for 1993–97. This fish loss equates to an estimated 0.93 million to 3.21 million kg (mean 2.07 million kg) of fish consumed per year, principally alewife (*Alosa pseudoharengus*, 42.3 percent) and yellow perch (*Perca flavescens*, 18.4 percent). Forage fish (alewife, cyprinids, trout-perch [*Percopsis omiscomaycus*], and other minor components) accounted for 65 percent of the diet, and panfish contributed 34 percent of

the diet for the 5-year period. Game fish were minor components of the diet, in view of an average estimated annual consumption of 900,000 smallmouth bass (*Micropterus dolomieu*, 1.1 percent) and 168,000 salmonines (mostly lake trout, *Salvelinus namaycush*, 0.2 percent). Cormorant predation on lake trout fingerlings stocked in May 1993 and June 1994 was estimated through the use of coded wire tag recoveries from pellets collected on Little Galloo Island 1 and 4 days after stocking events. We estimated losses of 13.6 percent and 8.8 percent, respectively, of the fish stocked for the two events, an average of 11.2 percent. Such losses may be reduced through alteration of existing stocking practices.

**Keywords:** alewife, *Alosa pseudoharengus*, coded wire tags, diet composition, digestive pellets, double-crested cormorant, gamefish, Lake Ontario, lake trout, Little Galloo Island, *Phalacrocorax auritus*, *Salvelinus namaycush*

In the Eastern United States, annual indices of abundance for the double-crested cormorant (DCCO) from Christmas Bird Count and Breeding Bird Survey data have shown exponential population increases since 1972 (Sauer et al. 1997). In Lake Ontario, breeding populations of DCCO's likewise have undergone dramatic changes since the first documented nesting on Scotch Bonnet Island in 1938 (Weseloh and Ewins 1994). The population grew to 218 nesting pairs in 1950 and then fell to 22 pairs in 1974. By 1987, monitors counted 3,471 pairs, an average annual population increase of 56 percent since 1974 (Carroll 1988). Presently about 15,000 pairs breed in Lake Ontario with no clear cessation of population growth (table 1).

Scientists believe the declines observed before 1974 were due largely to rising burdens of chlorinated hydrocarbons (especially the insecticide DDT and its metabolites) in the birds and the negative effects of these compounds on reproductive output (Price and Weseloh 1986). Other factors, such as human persecution and habitat loss, have also played a role in the decline (Craven and Lev 1987). By the mid 1970's, contaminant levels in cormorant eggs were reported to

**Table 1. Number of double-crested cormorant nests on eastern Lake Ontario, 1970–97**

| Year | Little Galloo Island | Other colonies | Total  |
|------|----------------------|----------------|--------|
| 1970 | 0                    | 2              | 2      |
| 1980 | 276                  | 99             | 375    |
| 1985 | 1,419                | 741            | 2,160  |
| 1992 | 5,443                | 3,383          | 8,829  |
| 1993 | 5,398                | 4,781          | 10,179 |
| 1994 | 3,745                | 5,151          | 8,896  |
| 1995 | 7,585                | 4,341          | 11,926 |
| 1996 | 8,410                | 6,400          | 14,810 |
| 1997 | 7,591                | 6,711          | 14,302 |

be falling while reproductive success began to increase (Weseloh et al. 1983). Simultaneously, legal protection was extended to cormorants through the Migratory Bird Treaty Act in 1972. Other hypothesized causes of the population resurgence include an abundant supply of nonindigenous forage fishes (alewife, *Alosa pseudoharengus*, and rainbow smelt, *Osmerus mordax*) and immigration (Price and Weseloh 1986).

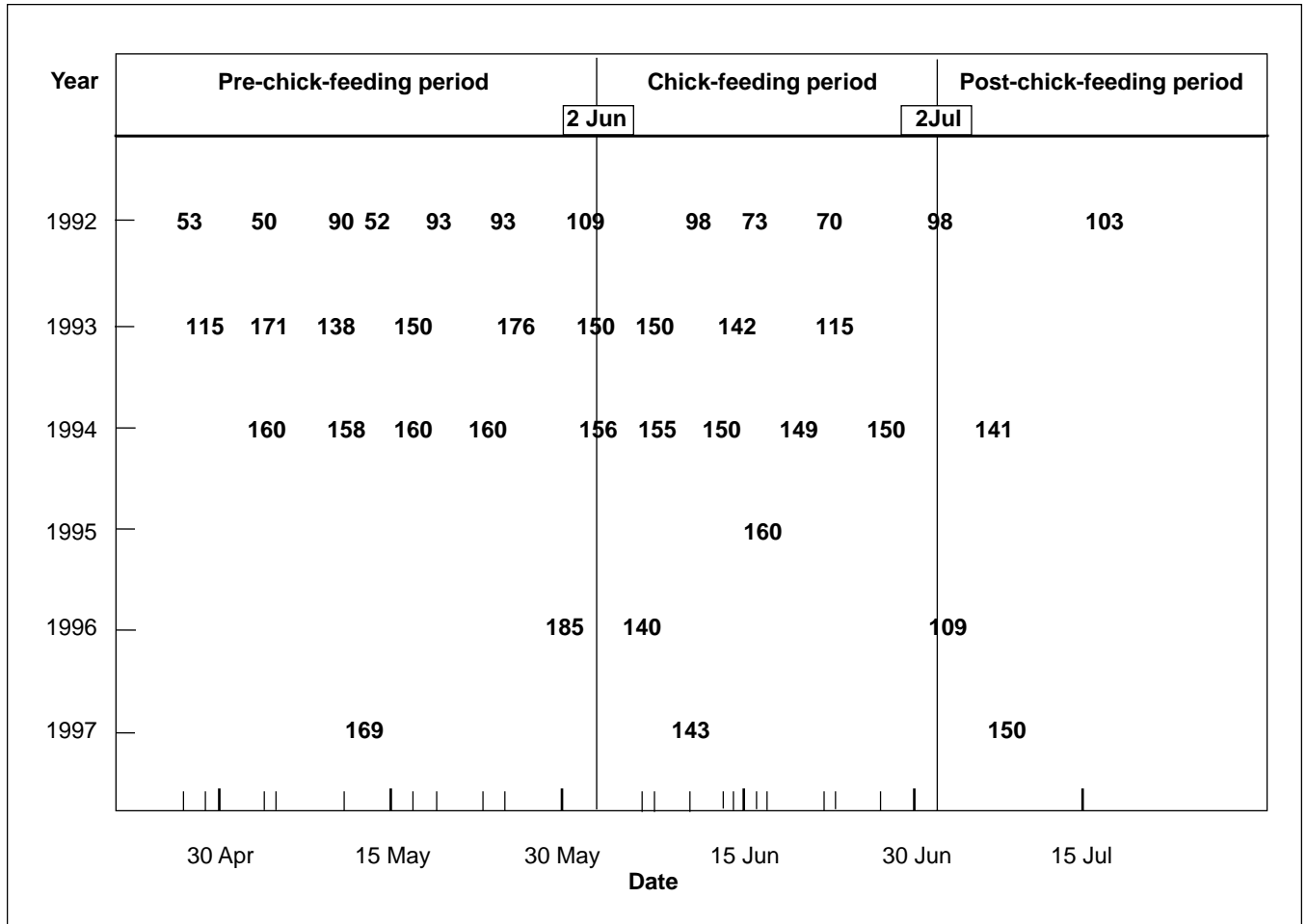
The expanded breeding population of DCCO's in Lake Ontario has led to an inevitable conflict between the sportfishing industry and bird enthusiasts as well as the resource agencies charged with protecting wildlife and assessing fish stocks. In the former category are such recently organized groups as the Concerned Citizens for Cormorant Control, whereas New York chapters of the National Audubon Society advocate absolute protection of cormorant breeding colonies. At stake for the sportfishing community in New York State alone is an annual catch of over 150,000 salmonines (1996 boat survey). The 1988 economic value of all sportfishing in New York waters of Lake Ontario was \$87 million (Connelly et al. 1988). The total commercial harvest for the same location in 1996 was 31,744 kg (principally yellow perch [*Perca flavescens*] and brown bullhead [*Ameiurus nebulosus*]) valued at \$70,000 (Cluett 1997).

A satisfactory resolution to the problem requires accurate information about the cormorant's life history, food habits, ecosystem role, and impact on other species of special concern. The U.S. Fish and Wildlife Service (FWS) and the New York State Department of Environmental Conservation (NYSDEC) asked us to monitor this system annually and to provide such information in advance of the difficult management decisions to be made in this high-profile fish and wildlife issue. Our objectives in this study were to (1) quantify daily fish consumption, (2) determine prey fish composition over the 6-year study period, (3) quantify annual fish losses (including sport fishes), (4) determine impact on lake trout stocking efforts, and (5) elucidate management implications.

## Methods

### **Study Site and Pellet Collection**

We determined diets by identifying the undigested remains found in regurgitated pellets at nest sites on Little Galloo Island in eastern Lake Ontario. Cormorant pellets consist of hard tissues such as bones, otoliths (ear stones), scales, and eye lenses, with the entire contents wrapped in a gelatinous mucus coating nearly the size of a golf ball. A single pellet is normally produced by each adult before the day's foraging trip (Craven and Lev 1987, Orta 1992). Knowledge of the pellet production rate is key to estimating total catches of fish by cormorants. Pellets were sampled weekly by NYSDEC personnel between late April and mid-July from 1992 through 1996. Little Galloo Island is a 17-ha, flat, nearly treeless island with more than 7,000 nests distributed in small groups across the island, mostly around the perimeter. A power analysis showed that, given the variability observed in the taxa represented in each pellet during 1992, approximately 150 pellets were needed to discern statistically significant differences between samples for all prey categories. Thus, approximately 150 fresh pellets were collected in less than 1 hour on each sample date by 2 people walking through most of the nest groups around the island. After 1994, to minimize disturbance of the colony, only one sample was obtained from each of the three phases of the nesting cycle (prechick feeding, chick feeding, and postchick feeding); in 1995 only one phase was sampled to minimize disturbance of the colony (fig. 1). Potential diet shifts early (April) or late (August–September) in the season would not have been detected with this sampling design and could represent a source of error in annual fish loss estimates by species. Pellets were placed individually in plastic bags, frozen, and transferred to the laboratory, where they were placed individually in labeled cloth bags and stored in 70 percent ethanol until processed.



**Figure 1**—Number of pellets collected per sample from Little Galloo Island during each of three phases of double-crested cormorant nesting cycle, 1992–97.

### ***Pellet Processing and Fish Identification***

Before sample identification, a reference collection of known fish bones, otoliths, and scales was assembled from external sources as well as from defleshing known samples in the laboratory. To deflesh type specimens, we immersed individuals in a solution of sodium hydroxide ranging from 2.5 percent for 2 hours (small fresh specimens) to 15 percent for 1 week (large preserved specimens). Hard tissues were washed in a sieve of sufficiently small mesh size to recover the small otoliths as well as all bones, scales, and eye lenses.

Pellets were processed by placing each in a 212-micron sieve, breaking the pellet open with forceps, and separating the mass of fish parts from the coat of gelatinous mucus with a jet of water. All materials were then placed in a petri plate and separated with the unaided eye (largest diagnostic parts), under a magnifying lens, and under a dissecting microscope (smallest diagnostic parts). Diagnostic bones (cleithrum, opercle, preopercle, premaxilla, dentary, and tooth-bearing pharyngeal bones were most helpful), all otoliths, representative scales, and all eye lenses were removed from the samples and placed in

25-cm vials with 70 percent ethanol for later identification. Occasionally, tiny (1-mm-long) coded wire tags (CWT's) from hatchery-reared lake trout (*Salvelinus namaycush*) were found and saved.

To identify fish body parts, we used references or keys and type specimens. Important sources for bone identification included Eastman (1977), Hansel et al. (1988), and French (1993). The most useful reference on scale morphology was Lagler (1947); otherwise, we relied on type specimens for otolith identification. Eye lenses could not be identified to species but gave us total fish counts (number of lenses divided by 2) that often exceeded counts based only on bones or otoliths.

### Data Analysis and Fish Loss Models

In this report we summarize data from 1992 through 1997. Data from 1992 (Karwowski 1994) were used for annual diet composition but not for fish loss estimates. The total number of pellets analyzed for the 6 consecutive years was 982, 1,307, 1,538, 160, 434, and 427. For the same years, the total number of fish represented by the pellet contents was 6,136, 16,079, 16,087, 1,937, 4,732, and 6,377. We calculated the percent composition of pellet contents and number of fish per pellet by year and species or group of fish to illustrate qualitative (prey species composition) and quantitative changes in cormorant diets over time. Calculations or estimates are means unless reported otherwise. Our mean numbers of fish per pellet are probably underestimates because the otoliths and bones of the smallest ingested fish are completely digested (Johnstone et al. 1990).

To determine the impact of cormorant predation on total fish losses in eastern Lake Ontario for 1993 through 1996, we used a model similar to that of Weseloh and Casselman (1992 unpubl.) to estimate the annual number and weight of fish eaten by cormorants. This model incorporated cormorant age-class population size and residence time (time spent feeding in area), mean daily fish ingestion rates, a fecal pathway correction factor for fish not detected in pellets (Johnson and Ross 1996), and several assumptions based on values from the literature or personal communications from colleagues. We assumed that

(1) residence time for breeding adults, immatures, and young of year (YOY) was 158, 112, and 92 days, respectively (Weseloh and Casselman 1992 unpubl.); (2) number of immatures was approximately 10 percent of the adult population (D. V. Weseloh, pers. commun.); (3) the number of YOY cormorants is the product of the fledgling productivity estimate for the year and the number of active nests; (4) average prey-fish size of DCCO's in the Great Lakes was about 13.5 cm (Craven and Lev 1987); and (5) approximate wet weight of a 13.5-cm alewife or yellow perch (the two dominant prey species) was 25 g (Carlander 1969, Hildebrand and Schroeder 1972). The annual fish loss model, then, consisted of four equations:

$$C = \sum_{i=1}^3 n_i t_i \quad (1)$$

$$F = C \cdot p \quad (2)$$

$$F' = 1.042 C \cdot p \quad (3)$$

$$W' = F' \frac{25 \text{ g}}{\text{fish}} \quad (4)$$

where C = total cormorant feeding days, n = number of birds of each age class present, t = the residence time in days for each age class, i = the successive cormorant age class, F = the total annual number of prey fish consumed, p = the mean number of fish per pellet (average daily consumption per cormorant), F' = the total annual number of prey fish consumed, corrected for fecal pathway (Johnson and Ross 1996), and W' = the total corrected annual weight of prey fish consumed.

Because the model is linear in all terms, it is equally sensitive to variation in all its terms of equations (1) to (4) with two exceptions. If residence times (t) for only one or two of the three cormorant population cohorts changes by a given amount, then the

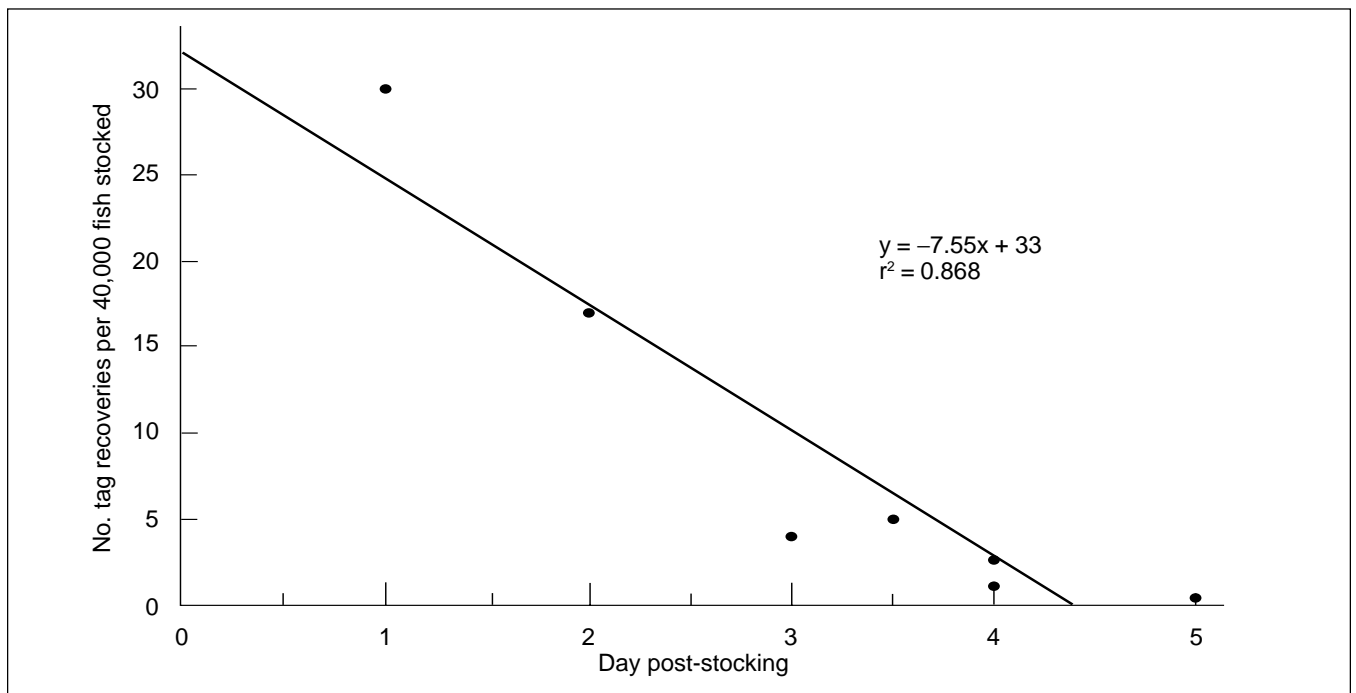
model is less sensitive to residence time than to the other model inputs. Similarly, the model is less sensitive to variation in fledgling productivity than it is to other inputs because fledgling productivity only affects a portion (the YOY cohort) of the “n” term.

To determine the impact of cormorant predation on lake trout stocked by the NYSDEC in 1993 and 1994, CWT recoveries from cormorant pellets were matched with specific stocking dates and locations. In 1993, the largest number of tag recoveries from a single stocking event was 30 tags, representing fish stocked at Stony Point on May 25 and recovered from pellets collected at Little Galloo Island on May 26. In 1994, only eight tags representing fish stocked at Stony Point on June 3 were recovered from pellets collected on June 7. To estimate the total number of lake trout taken by cormorants from these two stocking events from which sufficient tag-recovery data are available, we used the following known quantities: total number of fish stocked, one tag per fish stocked, total number of pellets collected after stocking, and total number of adult cormorants on island. We

assumed the production of one pellet per cormorant day and random collection of pellets from the island. The following proportion equation was then generated:

$$\frac{\text{percent of total daily pellet production sampled}}{\text{number of tags recovered}} = \frac{100\%}{X} \quad (5)$$

where X = number of tags in all pellets produced on the island and therefore the number of lake trout taken by cormorants from the stocking event. Because this estimate represents predation from only a single poststocking sample day, we recognized the need to increase such an estimate by the amount of predation occurring on at least a few additional poststocking days. We estimated this additional predation by plotting tag recoveries (in sampled pellets) from stocking events at the same locations (in May and June of 1993 and 1994) as a function of the number of days after stocking (fig. 2). Recovery rates were



**Figure 2**—Regression of the number of coded-wire-tag recoveries per 40,000 lake trout stocked in eastern Lake Ontario, 1993–94,

versus day after stocking. Regression equation parameters:  $r = 0.93$ ,  $p = 0.002$ .

standardized by expressing them as recoveries per 40,000 fish stocked. Seven stocking events contributed to the linear regression (a quadratic regression, perhaps giving a better fit, would have been unjustifiably complex given the few data points), which showed negligible predation after 4 days. We indexed relative predation levels over a 4-day period from the regression (day 1 = 45 percent of total predation, day 2 = 32 percent, day 3 = 18 percent, and day 4 = 5 percent) and adjusted estimates from tag recoveries from single predation days in 1993 and 1994 accordingly.

Results and Discussion

Annual Fish Losses

We observed 28 species of fish from pellet samples over the 6-year period. Inputs to the fishloss model showed high variability in fledgling productivity, moderate variability in adult and immature population levels, and relatively low variability in daily total fish consumption by cormorants (table 2). Minima for all three variables occurred in 1994. Outputs of the model showed considerable variation in interannual loss estimates, and the 1994 estimate (37.4 million) fell well off the mean of 82.8 million fish (table 2). The biomass associated with this mean number of fish is approximately 2.07 million kg for the eastern basin of Lake Ontario (table 2). Our 5-year average annual loss estimate is similar to the 1.75 million kg reported by

Weseloh and Casselman (1992 unpubl.) for the eastern basin. In the following paragraphs, we describe cormorant impact on three components of the lake fish community (forage, pan, and game fishes) independently.

**Forage Fish**—Forage fishes contributed about two-thirds of the diet of cormorants, and alewife (42 percent), cyprinids (9 percent), trout-perch (9 perch), and slimy sculpin (3 percent) were the major forage species consumed (table 3). Other forage species (e.g., coregonids, rainbow smelt) made up less than 1 percent of the diet of cormorants. On the basis of 6-year averages (1992–97), we estimate that DCCO’s consumed a minimum of 54 million forage fishes annually, including 35.0 million alewife, 7.8 million cyprinids, 7.2 million trout-perch, and 2.6 million slimy sculpin (tables 2 and 3).

The high incidence of forage species (especially alewife) in the diet of cormorants suggests the potential for competition with salmonine predators if the abundance of forage species declines. Reduced predation on alewife from 1992 to 1994 resulted in across-the-board increased predation on all other forage species except rainbow smelt, a trend reversed from 1994 to 1996. Rainbow smelt, which are common in Lake Ontario, were rarely eaten by cormorants, suggesting differences in the habitats utilized by smelt and foraging cormorants. Alternatively, smelt may exhibit effective escape or avoidance behavior with cormorants.

To put cormorant predation on forage fishes in perspective, we compared annual estimates of standing stocks of alewife and rainbow smelt in the eastern basin of Lake Ontario with the demand put on them by both resident salmonines and cormorants. Of the nearly 200 million kg of alewife and smelt available, 13.4 percent were consumed by resident salmonines, whereas only 0.5 percent were consumed by cormorants (Weseloh and Collier 1995). Using the more precise annual loss estimates from our 5-year data base (vice the 0.48 kg/day gross estimate for cormorant consumption), we calculated alewife and smelt demand to be 0.46 percent of the available biomass, which is very close to the figure of Weseloh and Collier

Table 2. Inputs and estimated fish losses for a model to estimate annual predation by double-crested cormorants in eastern Lake Ontario

| Year    | Inputs |                                | Mean fish/pellet | Fish loss estimate |                       |
|---------|--------|--------------------------------|------------------|--------------------|-----------------------|
|         | Adults | Productivity (fledglings/nest) |                  | Weight             |                       |
|         | Number | Number                         | Number           | Number             | (kg 10 <sup>6</sup> ) |
| 1993    | 20,358 | 2.0                            | 12.3             | 68.1               | 1.70                  |
| 1994    | 17,796 | 0.5                            | 10.5             | 37.4               | 0.93                  |
| 1995    | 23,852 | 2.75                           | 12.1             | 88.9               | 2.22                  |
| 1996    | 29,620 | 2.25                           | 10.8             | 90.9               | 2.27                  |
| 1997    | 28,604 | 2.6                            | 14.9             | 128.5              | 3.21                  |
| Average | 24,046 | 2.02                           | 12.1             | 82.8               | 2.07                  |



**Table 3. Percent composition of prey fish in pellets of double-crested cormorants from Little Galloo Island, 1992–97**

| Prey category and taxon | Year |                    |      |        |      |       |                   |  |      |       |      |         |
|-------------------------|------|--------------------|------|--------|------|-------|-------------------|--|------|-------|------|---------|
|                         | 1992 |                    | 1993 |        | 1994 |       | 1995              |  | 1996 |       | 1997 | Average |
| <b>Forage fish</b>      |      |                    |      |        |      |       |                   |  |      |       |      |         |
| Alewife                 | 46.8 | <sup>1</sup> (5.9) | 33.8 | (10.1) | 16.9 | (8.1) | <sup>2</sup> 55.1 |  | 60.3 | (5.9) | 41.0 | (17.0)  |
| Cyprinids               | 6.7  | (1.7)              | 12.7 | (4.3)  | 9.5  | (1.5) | 6.6               |  | 10.1 | (2.2) | 11.0 | (4.6)   |
| Trout-perch             | 9.0  | (2.7)              | 9.2  | (2.3)  | 17.9 | (3.6) | 5.6               |  | 6.5  | (1.4) | 3.9  | (1.6)   |
| Slimy sculpin           | 2.2  |                    | 1.3  |        | 5.3  |       | 5.8               |  | 1.0  |       | 3.1  |         |
| Other                   | 2.0  |                    | 1.5  |        | 1.4  |       | 1.8               |  | 1.6  |       | 0.6  |         |
| <b>Panfish</b>          |      |                    |      |        |      |       |                   |  |      |       |      |         |
| Yellow perch            | 7.6  | (1.6)              | 20.0 | (5.3)  | 26.1 | (5.3) | 16.2              |  | 14.2 | (2.6) | 26.2 | (9.4)   |
| Centrarchids            | 15.8 | (2.3)              | 15.5 | (3.3)  | 17.4 | (2.4) | 7.9               |  | 3.7  | (0.9) | 12.4 | (4.3)   |
| White perch             | 7.9  | (1.5)              | 3.9  | (0.1)  | 1.1  | (0.2) | 0.1               |  | 0.6  | (0.4) | 0.1  | (0.0)   |
| Ictalurids              | 0.7  |                    | 0.7  |        | 1.8  |       | 0.3               |  | 0.2  |       | 0.7  | (0.4)   |
| <b>Gamefish</b>         |      |                    |      |        |      |       |                   |  |      |       |      |         |
| Smallmouth bass         | 1.1  | (0.2)              | 0.9  | (0.6)  | 2.2  | (0.9) | 1.5               |  | 0.4  | (0.2) | 0.9  | (0.2)   |
| Salmonines              | 0.2  | (0.1)              | 0.5  | (0.3)  | 0.4  | (0.1) | 0.0               |  | 0.1  | (0.1) | 0.1  | (0.0)   |

<sup>1</sup>Numbers in parentheses denote standard errors.<sup>2</sup>Standard errors were not calculated for 1995 (single sample only that year).

(1995). Clearly, the competition of cormorants with resident salmonines for forage fishes is insignificant.

**Panfish**—Panfish made up about one-third of the diet of cormorants, led by yellow perch (18 percent), centrarchids (12 percent), and white perch (*Morone americana*, 2 percent) (table 3). Ictalurids (mostly brown bullhead) comprised less than 1 percent of the diet of cormorants over the 6-year period. Increased predation on panfishes occurred from 1992 to 1994 and was probably associated with declining numbers or reduced availability of alewife. In 1992, panfish constituted 31 percent of the diet of cormorants, and consumption increased to 45 percent by 1994. Over the 6-year period, yellow perch were the second-most abundant prey species in the diet of cormorants, and the data show a clear trend of increased utilization of yellow perch from 1992 to 1994 as the dominant prey, alewife, decreased in the diet. By 1996, however, this trend was completely reversed. The annual consumption of panfish by cormorants during the 6-year period was about 27.7 million fish: principally 15.2 million yellow perch, 10.0 million centrarchids, and 1.9 million white perch.

**Gamefish**—Gamefish, mainly smallmouth bass (1.1 percent) and salmonines (0.2 percent), made up only 1.3 percent of the diet of cormorants from 1992 to 1997 (table 3). Almost all of the salmonines identified were stocked lake trout. We estimate that cormorants consumed about 1 million gamefish annually. Most (900,000) were smallmouth bass, but about 168,000 salmonines may also have been eaten.

### **Losses Associated With Lake Trout Stocking Events**

The highest detectable incidences of predation on lake trout occurred when a stocking event in the eastern basin of Lake Ontario immediately preceded pellet collection on Little Galloo Island (fig. 2). In the 1993 and 1994 seasons, lake trout remains (otoliths, bones, and scales) and the presence of CWT's, which identify stocking location and date, allowed us to generate loss estimates that could be associated with a particular stocking event. In 1993, 30 CWT's appeared in pellets collected 1 day after a stocking event at nearby Stony Point on May 25, giving an estimate of 5,464 lake trout



(13.7 percent of the stocking) consumed by cormorants over a 4-day period following the event. Only nine CWT's were recovered from cormorant pellets in 1994, all on June 7. Eight tags recovered on June 7, 1994, from fish stocked on June 3 at Stony Point resulted in an estimate of 10,320 lake trout eaten, or about 8.8 percent of the number released on June 3. Average losses for the two stocking events were 11.2 percent.

## Management Implications

Dietary analyses of DCCO's in the eastern basin of Lake Ontario from 1992 to 1997 showed substantial annual variation in diet composition that may reflect differences in the relative abundance or availability of prey fishes among years. For example, our data suggest that in the eastern basin of Lake Ontario, populations of alewife (at least through 1994) and white perch may have decreased, whereas native coregonids may have increased slightly. However, there is evidence to suggest that, at least in 1994, low consumption of alewives may have been due to lake temperatures. Low surface temperatures in the spring may have restricted alewives to depths that were too deep for cormorants to forage.

Whether a declining or less-available population of alewife in Lake Ontario was a factor or not, fish consumption in 1994 was apparently less than in 1993. About two fewer fish per pellet were enumerated from cormorant pellets in 1994 (12.3 in 1993 versus 10.5 in 1994), and lower fish consumption was probably a major cause of the sharp drop in chick productivity in 1994 (2.0 chicks/nest in 1993 v. 0.5 chick/nest in 1994). Decreased availability of alewife may also have increased foraging time or range, thus increasing energetic demands of adults.

Although cormorants' overall fish consumption declined by 45 percent in 1994 from the previous year, predation on some species increased in terms of apparent effort expended by cormorants. In 1994, slimy sculpin increased in the diet fourfold, smallmouth bass twofold, trout-perch twofold, yellow perch by 31 percent, and centrarchids by 12 percent. Our data suggest that these species may have experienced increased predatory effort by cormorants as a result of decreased availability of alewife. Although the contribution of yellow perch in the diet of cormorants increased from 20 percent in 1993 to 26 percent in 1994, when it was the major prey species, our estimate of yellow perch consumption in 1994 (9.8 million fish) was lower than that in 1993 (13.6 million fish), owing largely to a smaller and less productive cormorant population.

We found that 9 to 14 percent of lake trout from an individual stocking event were consumed, and almost half of the total predation occurred within 1 day of release. Cormorant depredation rates as high as 50 percent on Atlantic salmon smolts stocked in the Machias River in Maine have been reported (Meister and Gramlich 1967). Because almost half the predation by cormorants occurs soon after release, alteration of certain stocking practices may significantly reduce predation. Johnson and Ringler (1995) found that predation on recently released American shad (*Alosa sapidissima*) larvae by fish predators was highest immediately following release and suggested that altering stocking practices (temporally, spatially or both) was the most reasonable means to reduce predation.

Control of cormorant populations has been undertaken in instances of high predation on gamefish (Meister and Gramlich 1967). However, in the eastern basin of Lake Ontario, gamefish contributed only 1.3 percent of the diet of adult cormorants from 1992 to 1997. Data from 1994 suggest that reduced availability of alewife may be acting as a natural biological control governing cormorant populations in Lake Ontario.

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